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AN INTELLIGENT AND CO-OPERATIVE DRIVER SUPPORT SYSTEM FOR VEHICLES IN ROAD ENVIRONMENTS TO ENHANCE PUBLIC SAFETY

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ABSTRACT

Recent technological advancements and the prosperity towards participating in them necessitate people and possessions to be mobile. Efficient systems are needed for enhancing the security in transportation systems. Enforcing measures to ensure road safety is of paramount importance in order to avoid thousands of deaths each year. Accidents that are caused due to human errors put not only the life of the driver at risk, but also the lives of those around him. The Co-operative Driver Support System (CDSS) proposed in this paper deals with two phases: abnormality detection and automatic assistance. The first phase deals with the detection of drunkenness, drowsiness and abnormal heart beat, whereas the second phase alerts the driver based on the detection along with automatic control of the vehicle, if necessary. The system also sends the detected information along with the location to the driver's caretaker over GSM. The proposed system has been implemented on an electric car prototype and tested using PIC16F877A and MPLAB IDE v8.91, which uses HiTech Compiler v9.65.

***KEYWORDS**: Driver Safety, Support System, Drunkenness Detection, Drowsiness Detection, Heart Beat Detection, Automatic Control, Gsm, Pic16f877a & Mplab Ide*

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Original Article

INTRODUCTION

India is one of the countries having highest motorization growth rate in the world. This coupled with the rapid expansion in road network and urbanization seriously endangers the public safety on road. Road accidents and fatalities have come up as a major public concern, as it is one of the leading causes of death and permanent disability in the country. According to the Ministry of Road Transportation and Highways, over 1300 accidents take place every day on Indian roads, out of which about 400 result in fatalities (TRW, 27/02/2019). Research shows that the main cause of accidents and crashes are human errors like over speeding, drunken driving, distractions while driving, avoiding safety gears, non-adherence to lane driving, overtaking in a wrong manner, etc. It is reported in recent studies that about 4.6% of the total road accident fatalities were caused due to an intoxicated driver (TRW, 27/02/2019). It has also been observed that 0.5% of road accident fatalities were caused due to the driver falling asleep behind the wheel or being sick (TRW, 27/02/2019). These statistics prove that there is an urgent need of a remedial measure to curb the unnecessary loss of lives. Enforcement of different road safety

measures is put into action to reduce the rate of accidents. But there are certain circumstances, which are beyond the reach of law enforcement's precautionary measures. For example, there is no way to predict whether a driver is going to fall asleep while on road, or whether he is going to suffer from an unavoidable medical condition such as a heart attack. This gives rise to the need of sophisticated and intelligent driver assistance systems, which can detect such abnormal situations and tackle with them appropriately.

In this paper, we are proposing an intelligent, Co-operative Driver Support System (CDSS) which monitors the signals from different sensors implanted in and around the vehicle to support the driver. The proposed methodology will screen and alert the driver for signs of intoxication as soon as he/she gets into the car. Also, it will continuously observe the driver's heart beat rate to check for signs of an imminent heart attack and also, drowsiness. If any discrepancy is detected, the control of the vehicle will shift from the normal driver mode to the CDSS mode and the driver will be notified with warnings. If no response received from the driver for a certain pre-threshold time, the CDSS would perform automatic halt of the vehicle and inform a caretaker of the same along with the location of the driver over GSM.

The paper is organized as follows; the existing driver assistance systems are discussed in section 2. Section 3 describes the system architecture of the Co-operative Driver Support System (CDSS). The working methodology of CDSS is elucidated in section 4. Section 5 discusses the implementation results of the CDSS and the paper is concluded in section 6 by discussing the scope for future work.

RELATED WORK

The objective of driver assistance systems is to enhance the efficiency of the present day traffic conditions. The efficiency enhancement in automobile's point of view is focussing on improving the driver's behaviour to reduce the environmental impacts, but these behaviours will lead to public safety also. It requires efficient co-operative systems to exchange information from the internal sensors of the vehicle with the driver and the automobile's control unit. These cooperative systems perform fusion of the sensor information which tends towards the autonomous driving. Vaishnavi et al. have developed a system which detects the consumption of alcohol by a driver. The motors work according to the threshold provided by the user. One of the drawbacks of the system is that it makes the user set the threshold level through a keypad. Moreover, it does not ask the user to set a Blood Alcohol Content (BAC) level. Instead it asks the user to set the threshold in terms of the digital values given by the sensor. This might lead to setting up of inaccurate threshold level. Secondly, they use an MQ2 sensor to detect alcohol. Although MQ2 sensor is sensitive to ethanol, MQ3 sensor is specifically designed for that purpose and is a better option.

Nimmy James et al. have also developed a system which can be integrated with a car to check how intoxicated the driver is. Their system starts checking for sensor readings after the ignition has been turned on. Subsequently, if the readings cross the threshold, the motors will be disconnected from the system. One disadvantage of this system is that it cannot check for sensor readings without turning on the ignition. This means that the car will be in motion till the sensor is able to detect alcohol in the driver's breath. Another initiative (NHTSA, 27/02/2019) is taken by a research group called Driver Alcohol Detection Safety System which explores two technologies, namely, breath based system and touch based system. The breath based system is a non-invasive method which uses an infrared light beam on the breath sample. This is done to calculate the alcohol concentration by analysing the wavelengths returned back. The touch based system, as the name suggests, samples the skin's surface, and specifically the capillaries to check for alcohol presence beneath them.

Sharad et al. have used a camera inside the car to monitor the eye movements and face tilts of the driver. The system will look for any physical and physiological changes in the driver. The important point here is that the camera should be turned on whenever the ignition is turned on. Additionally, the system should be self-sufficient and should not wait for any feedback from the driver. Itenderpal Singh et al. also have developed a system that observes eye movements of the driver. They have installed a camera to capture images of the driver's face. They observe the eye movements to determine whether or not the driver is sleep. The drawback of the system is that eye movements cannot always give an accurate result. For instance, even the eye size would greatly affect the observations.

PROPOSED CO-OPERATIVE DRIVER SUPPORT SYSTEM (CDSS)

System Model

Sensor based support systems in the design of automobiles will be helpful for providing automatic assistance to the driver, as they are capable of fusing the individual sensor data and interchanging the data with the automobile's decision/control units. The proposed Co-operative Driver Support System (CDSS) is a sensor based system which is liable for conserving control, stability and manoeuvrability of the vehicle during danger situations. The proposed system has been analysed with the help of a prototype for the interaction between the various elements involved in driving, perception and communication which also considers the dynamic conditions of the vehicle. The system model for the proposed CDSS is shown in Figure 1.

The proposed CDSS consists of two phases – the first phase deals with the abnormality detection system which consists of a MQ3 sensor, a pulse sensor and controller PIC16F877A, whereas the second phase called automatic assistance system consists of GSM/GPS integrated module, motors, buzzer and LEDs. The automatic assistance module depends on the input receives from the abnormality detection unit. The PIC microcontroller analyses the readings received, before sending a control output to the automatic assistance system. The readings taken by pulse sensor help in the detection of both, abnormal heart rate and drowsiness.

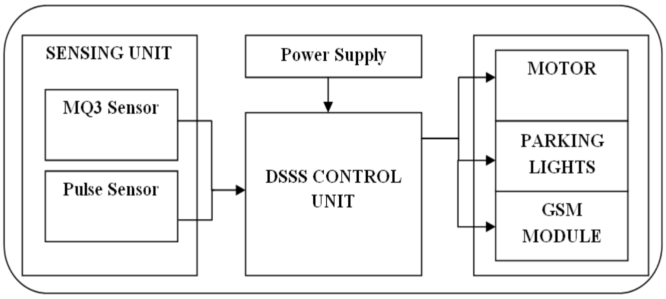

Figure 1: System Model of CDSS

The alcohol sensor MQ303A is used to detect the alcohol content. It operates on the heat transfer principle to measure mass air flow. Heart rate sensor continuously monitors the heart rate variability of the driver. The heart rate sensor along with flexi force pressure sensor detects the driver's fatigue level. The system has a GSM modem with a SIM card. The driver needs to activate call divert to the SIM number before entering the CDSS mode. In this mode, upon receiving an incoming call while driving, the GSM modem automatically sends an SMS to the calling number with a fixed message indicating that the person has been driving. The system has a dashboard Graphics LCD that can show the calling number. This makes the driver 100% hands free while driving.

The software architecture of the CDSS system was built on MPLAB IDE v8.91. The code for PIC16F877A was compiled using HI-TECH C Compiler v9.65. The readings from MQ3 sensor are taken only once when the driver enters the car. The sensor initially takes 25 values before testing the driver's breath. Then the 25th value is treated as a reference value to determine the presence of alcohol content.

But the readings from pulse sensor are analysed at a regular interval. The algorithm uses an interrupt every 2ms to sample the pulse waveform. This sampling rate is chosen to make sure that we do not analyse the high frequency noise associated with very high sampling rates and also to make sure that it is not small enough to miss out on any peaks.

Finally, if any aberration is noticed, the system promptly activates the GSM/GPS module to send an SMS to the caretaker of the driver. The SMS will include the type of emergency encountered along with the GPS location of the incident.

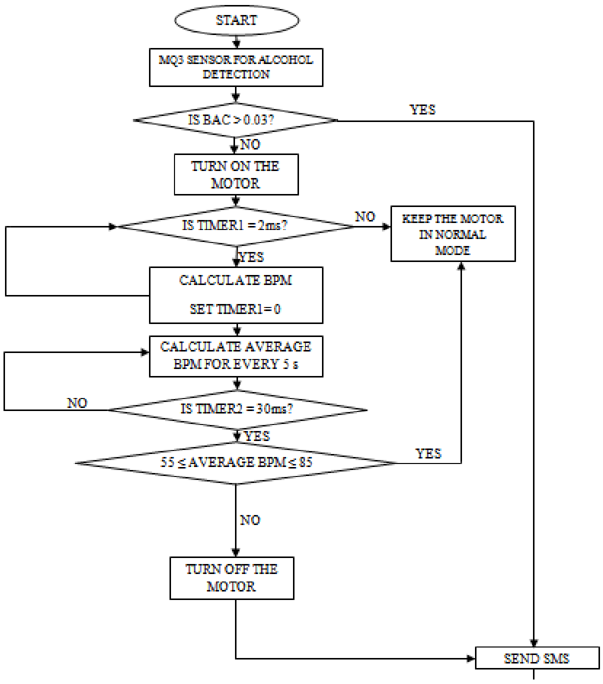

Figure 2: Flow Digram of the Proposed CDSS Algorithm

CDSS Algorithm

The detailed flow chart of the proposed CDSS algorithm is depicted in Figure 2. As soon as power supplied to the electric car prototype, the MQ3 gas sensor starts taking values. It checks for the blood alcohol concentration (BAC) of the driver from the blown air. If it is less than 0.03, it switches on the motors. The system checks for alcohol in the driver's body only once. If it is determined that the driver is not intoxicated, the system moves on to check for the pulse rate of the driver. Else, the car does not move at all and an SMS is sent to the caretaker along with the location. Once the system starts taking values from the pulse sensor, it calculates a BPM value for every 2ms.

It also keeps taking the average of BPM values every 5 seconds, and stores it in a new variable for a span of 30 seconds. Studies reveal that 27 seconds before a person fall asleep, his/her heart rate increases steadily (Felipe Jiménez et al., 27/02/2019). Therefore, the BPM is being monitored over a span of 30 seconds. To ensure accuracy of the system, an average of all values is taken for every 5 seconds to compensate for any stray value. If the BPM is less

than 55 or greater than 85, the system will send a warning signal to the driver and if no proper response received from the driver side, the CDSS will make the car come to a halt. Upon detecting any abnormal conditions, an SMS will be sent to the caretaker along with the driver's location to alert them of the driver's health condition.

RESULTS

The proposed CDSS algorithm was tested distinctly for each module. The prototype of the proposed CDSS is shown in Figure 3. As the system requires the driver to blow into the sensor to start the car, many trial runs were done to establish the number of units by which the ADC value increases. After several trials, it was determined that the ADC value increases at least by 15. Therefore, the working algorithm checks whether the reading taken by the MQ3 sensor is at least 15 more than the reference value.

Since it was not possible to obtain alcoholic beverages, 99.9% pure ethanol was used to check how the MQ3 reacts when the test liquid is at different distances. The 6ml ethanol was dissolved in 20ml distilled water to check how close the sensor needs to be to detect alcohol. When the MQ3 sensor was approximately 5cm away from the liquid, the MQ3 gave a positive result for the presence of ethanol.

The timer module of the PIC16F877A was set with a pre-scalar of 2. It was observed that with this configuration, the 8 bit timer of the microcontroller went from 0 to 255 in 0.1ms. This poses a challenge because the sampling rate of 0.1ms would have been too high. In order to avoid the high frequency noise, an additional loop was introduced in the interrupt routine. This loop had a counter variable set to 20. Therefore, if the interrupt was called 20 times, only then the pulse sensor would start taking readings.

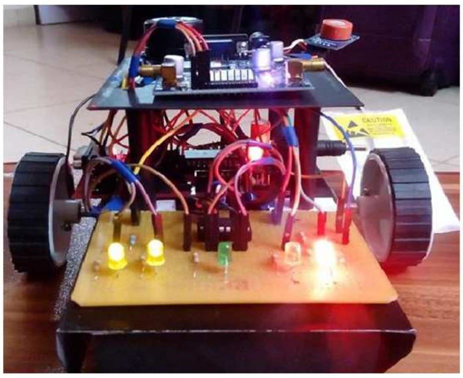

Figure 3: Prototype of Proposed CDSS

The GPS module has an antenna with a frequency of 1575.42MHz. The GPS module does not work well in closed spaces. Therefore, it needs to be placed in an open space to allow it to connect to satellites and give the location as precisely as possible. The abnormality detection for drunkenness and variable heart rate is indicated using green and red LEDs simultaneously in Figures 4(a) and 4(b). Upon detecting any abnormality, the system will automatically switch into CDSS mode and send sms over the GSM network to the driver's caretaker. The sms includes the GPS location of the driver, which is indicated in Figure 5.

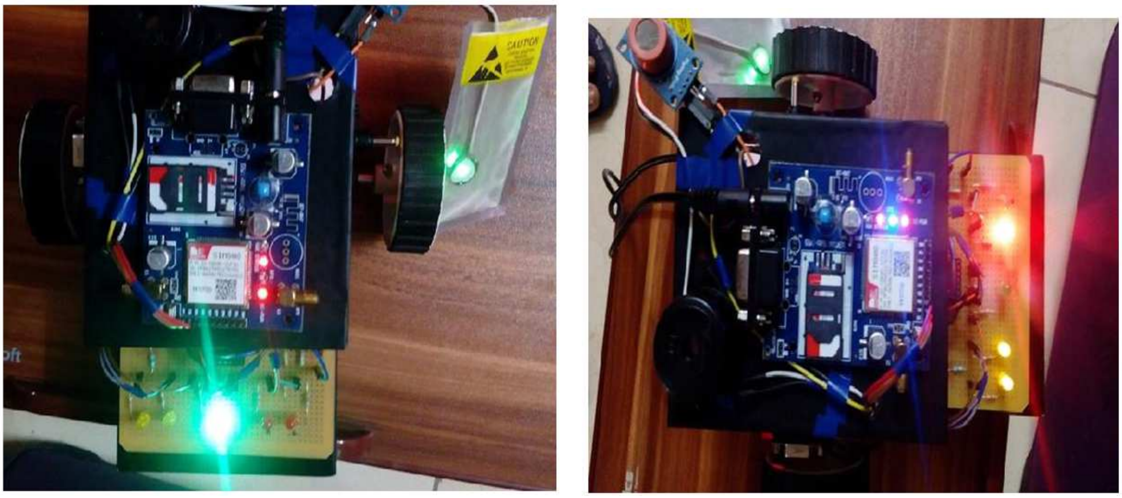

Figure 4(a) & 4(b): Abnormality Detection

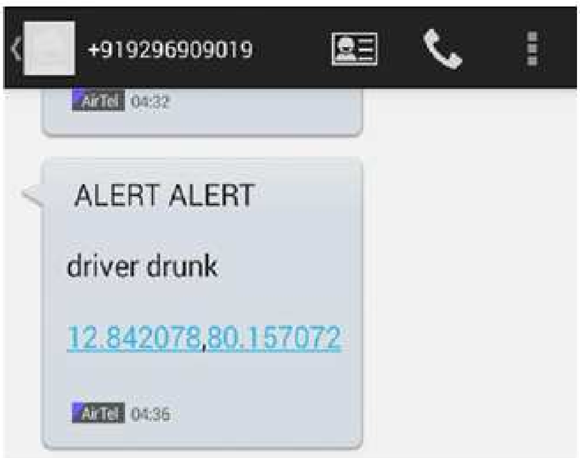

Figure 5: Automatic Message with GPS Location

CONCLUSION AND FUTURE WORK

A smart control over the vehicles is one of the current challenges of intelligent transport systems. The sensor integrated automatic driver assistance systems involve complex perception and sensor fusion. The high complexity involved in such systems demands for a reliable, fast and effective support system. This paper presents an intelligent, CDSS mechanism which can be extended in large extent which will help in preventing road accidents to a larger extent. The control mechanism of the system can be linked to the motors of the mechanical car. Also, to implement it in real time, the system can be equipped with cameras that could screen the roads for traffic and people nearby and bring the car to a halt gradually instead of stopping it immediately. Thus, the prototype can be implemented in real time to save precious lives.

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